Title: A Hybrid Neural Network And Support
Vector Machine Method For Optimization
SN: 10/043,044
Inventor: Man Mohan Rai
NASA ARC Docket No.: ARC-14586-1
POC: Vickie L. Kent (650) 604-0887

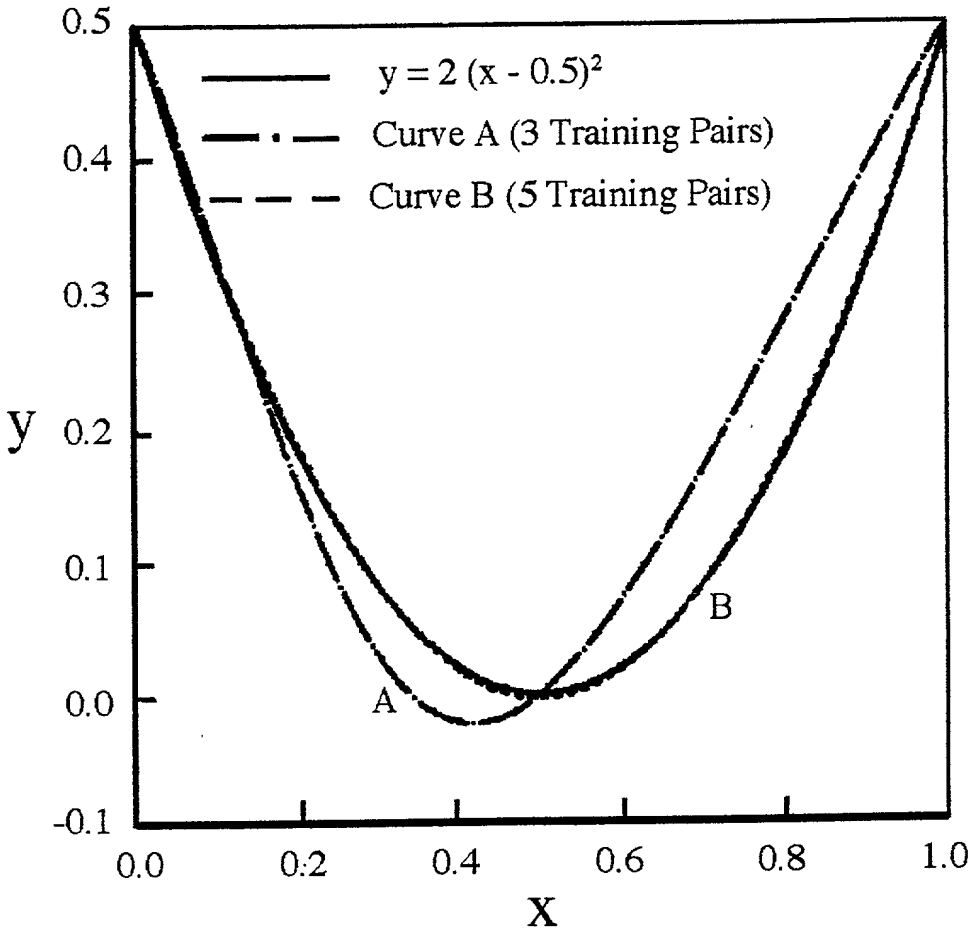

FIG. 1

Title: A Hybrid Neural Network And Support
Vector Machine Method For Optimization
SN: 10/043,044
Inventor: Man Mohan Rai
NASA ARC Docket No.: ARC-14586-1
POC: Vickie L. Kent (650) 604-0887

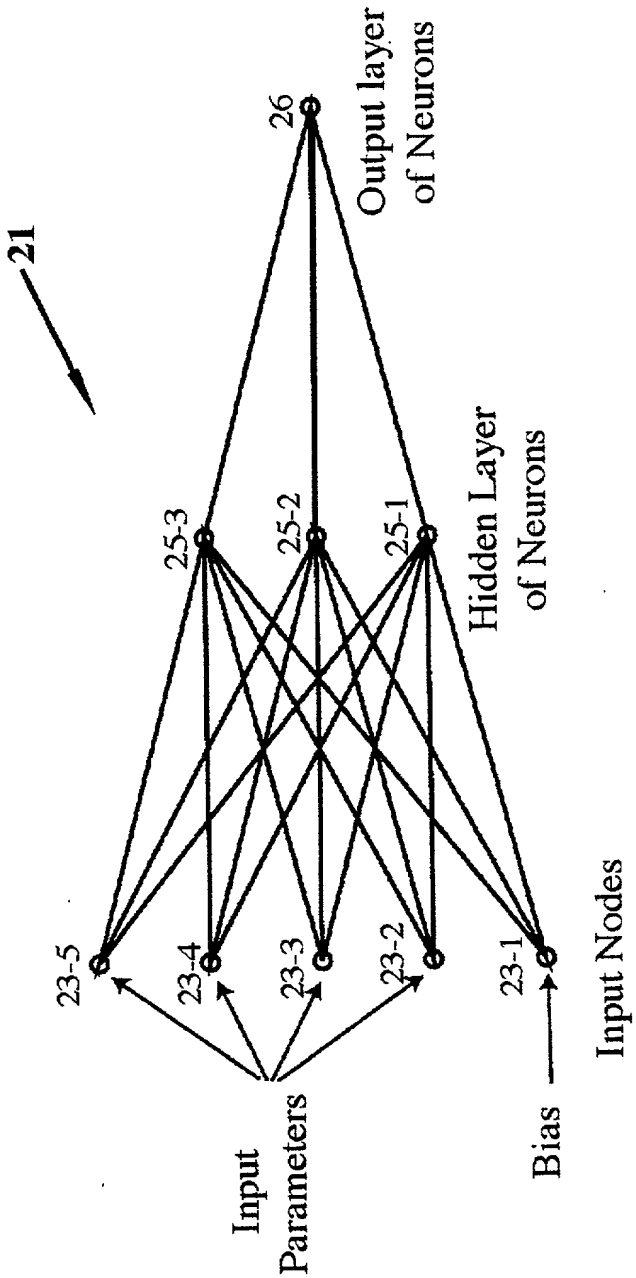

FIG. 2

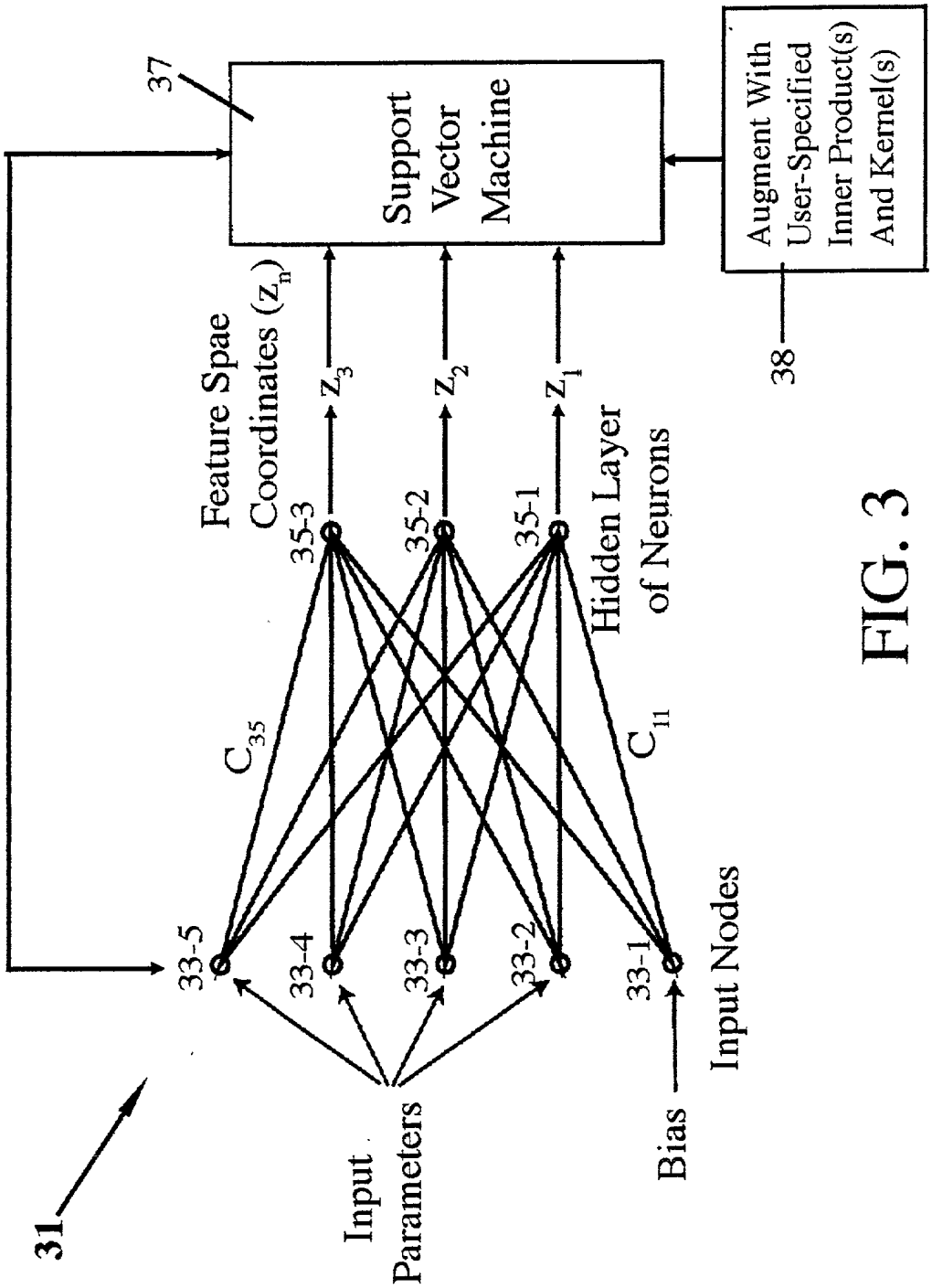
31
Input Parameters
Bias
Input Nodes
33-1
33-2
33-3
33-4
33-5
C_{11}
C_{35}
Hidden Layer of Neurons
35-1
35-2
35-3
z_1
z_2
z_3
Feature Spae Coordinates (z_n)
37
Support Vector Machine
38
Augment With User-Specified Inner Product(s) And Kernel(s)

FIG. 3

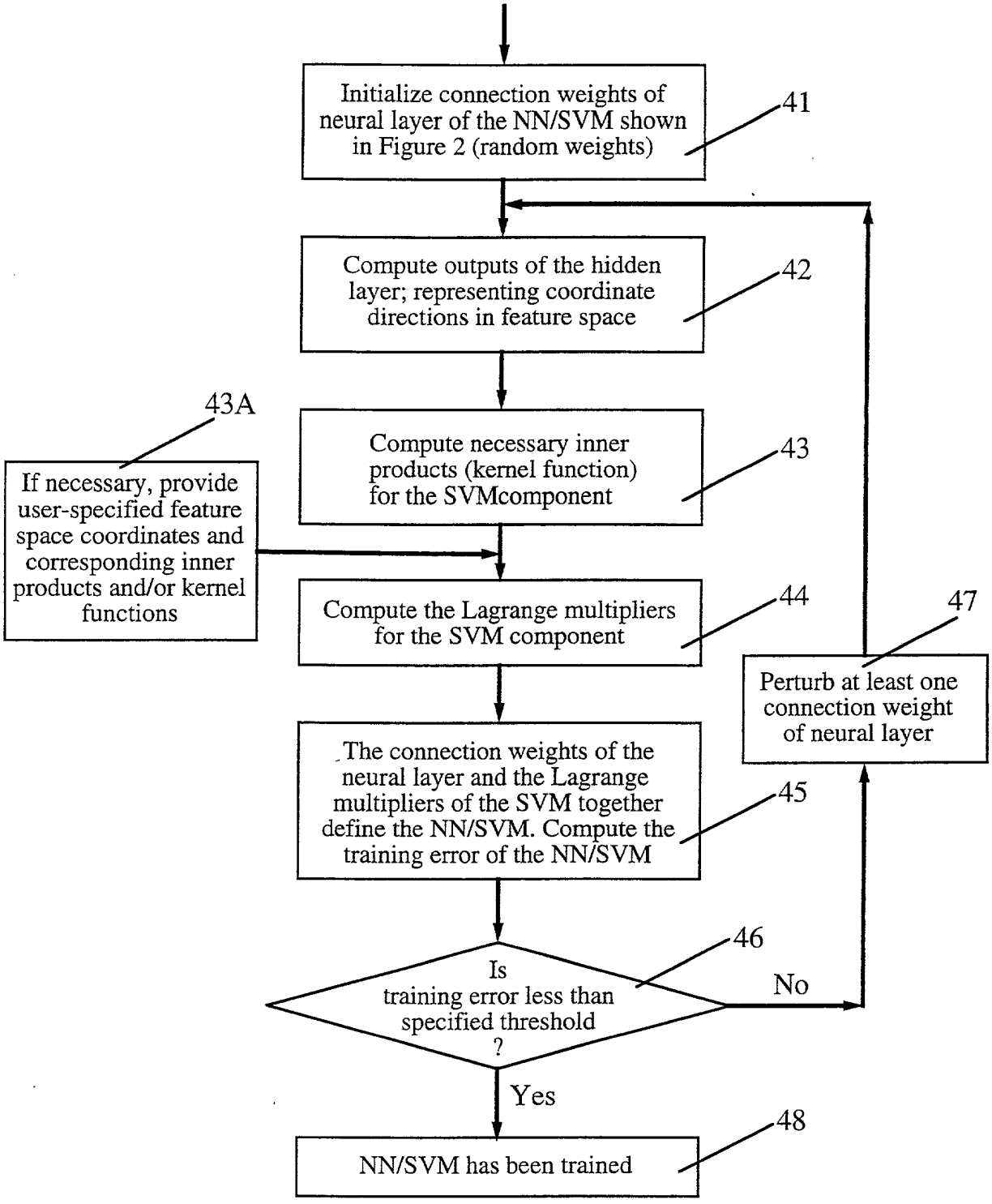
Initialize connection weights of neural layer of the NN/SVM shown in Figure 2 (random weights)
41
Compute outputs of the hidden layer; representing coordinate directions in feature space
42
43A
If necessary, provide user-specified feature space coordinates and corresponding inner products and/or kernel functions
Compute necessary inner products (kernel function) for the SVMcomponent
43
Compute the Lagrange multipliers for the SVM component
44
47
Perturb at least one connection weight of neural layer
The connection weights of the neural layer and the Lagrange multipliers of the SVM together define the NN/SVM. Compute the training error of the NN/SVM
45
46
Is training error less than specified threshold ?
No
Yes
48
NN/SVM has been trained

FIG. 4

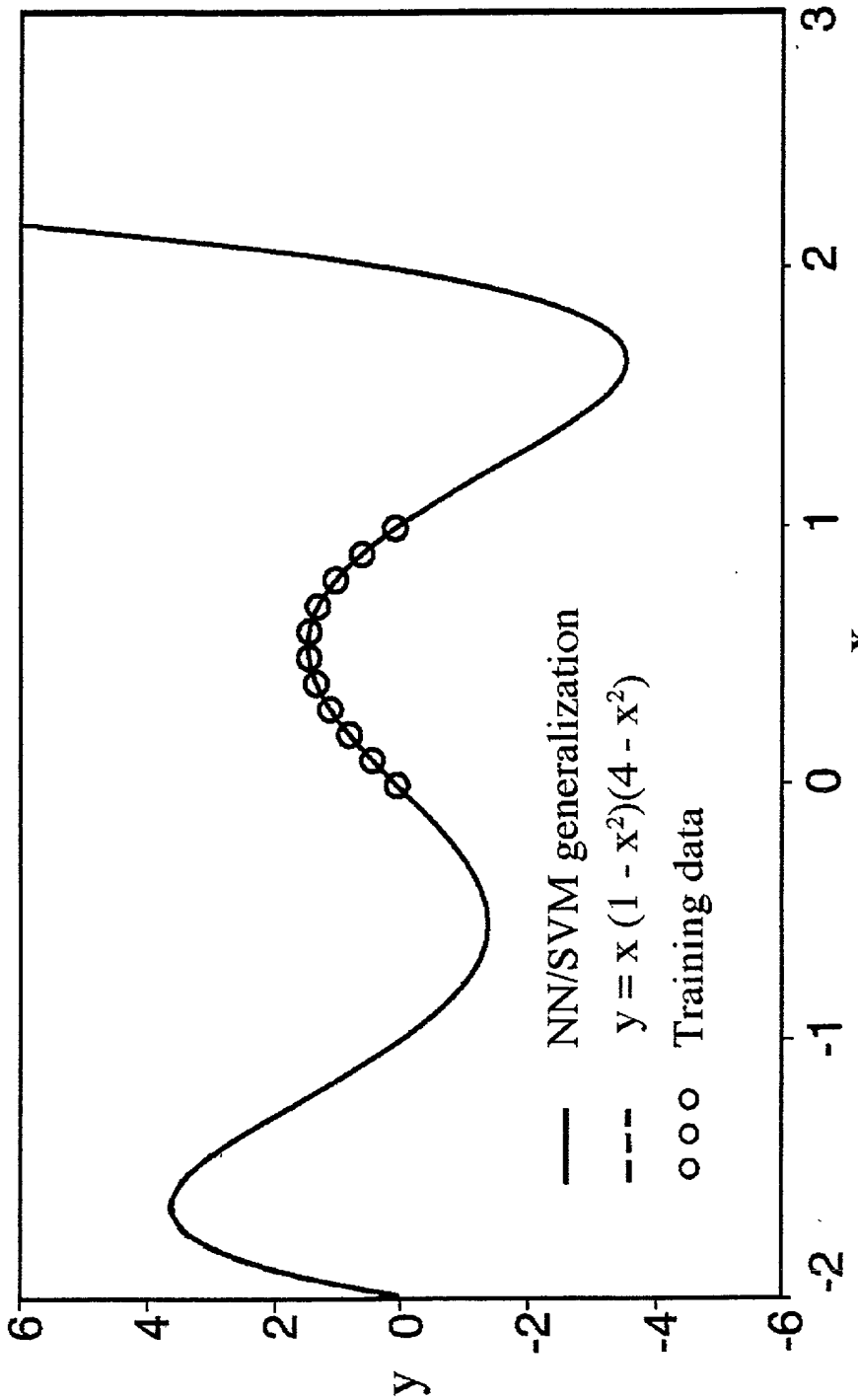
NN/SVM generalization
y = x (1 - x²)(4 - x²)
Training data
y
x
6
4
2
0
-2
-4
-6
-2
-1
0
1
2
3

FIG. 5

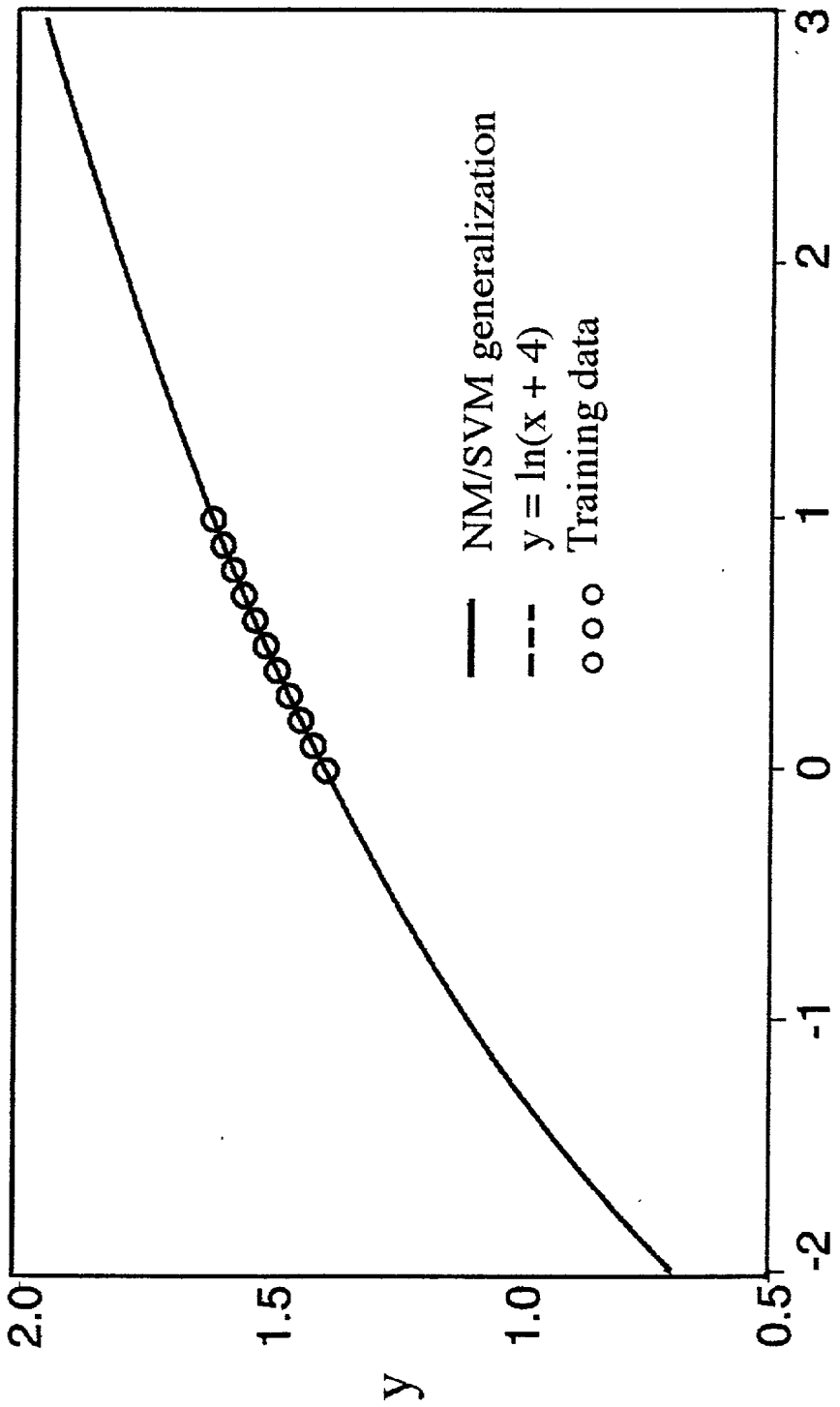
NM/SVM generalization
y = ln(x + 4)
Training data
y
x
2.0
1.5
1.0
0.5
-2
-1
0
1
2
3

FIG. 6

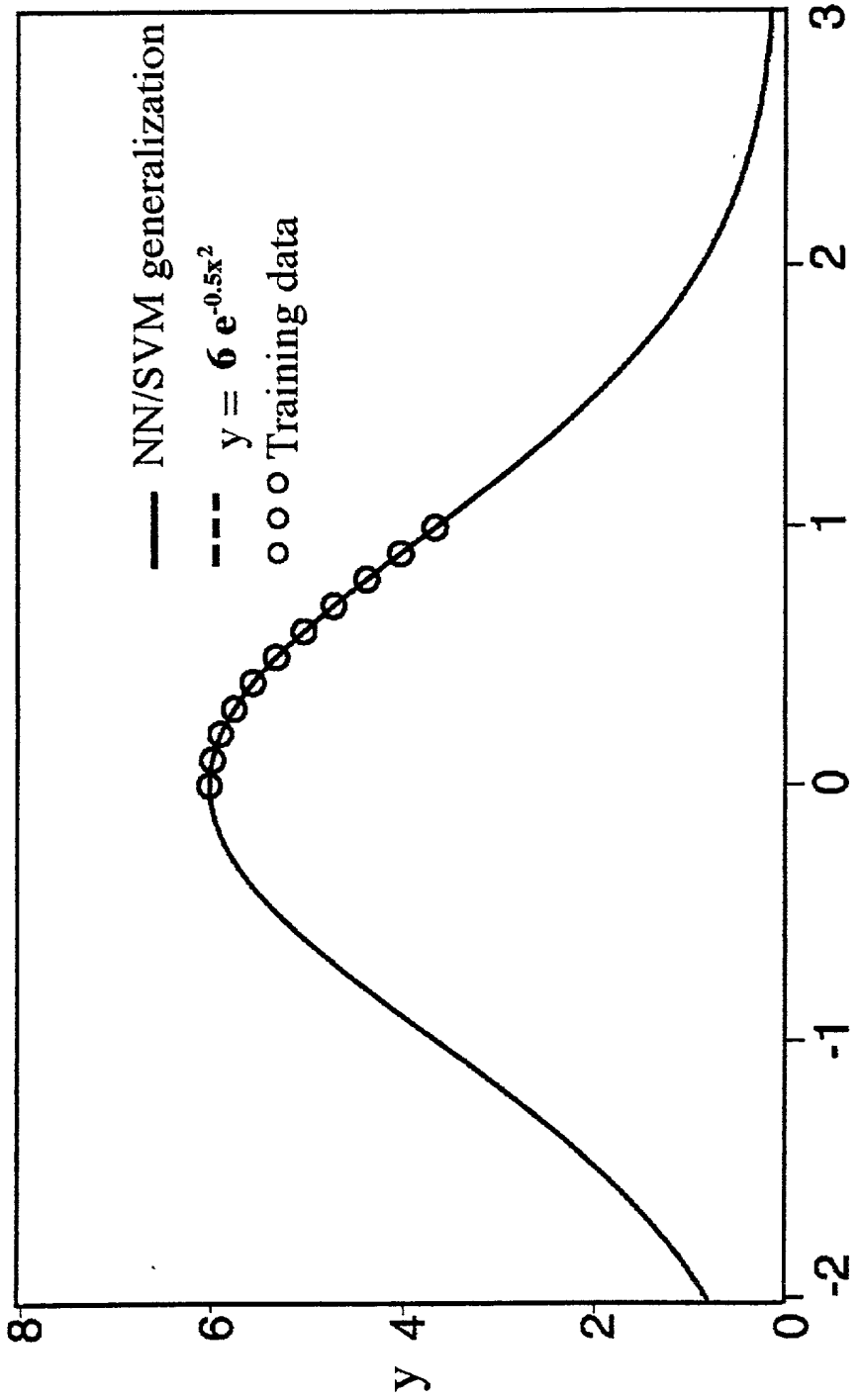
NN/SVM generalization
$y = 6\ e^{-0.5x^2}$
Training data
y
x
8
6
4
2
0
-2
-1
0
1
2
3

FIG. 7

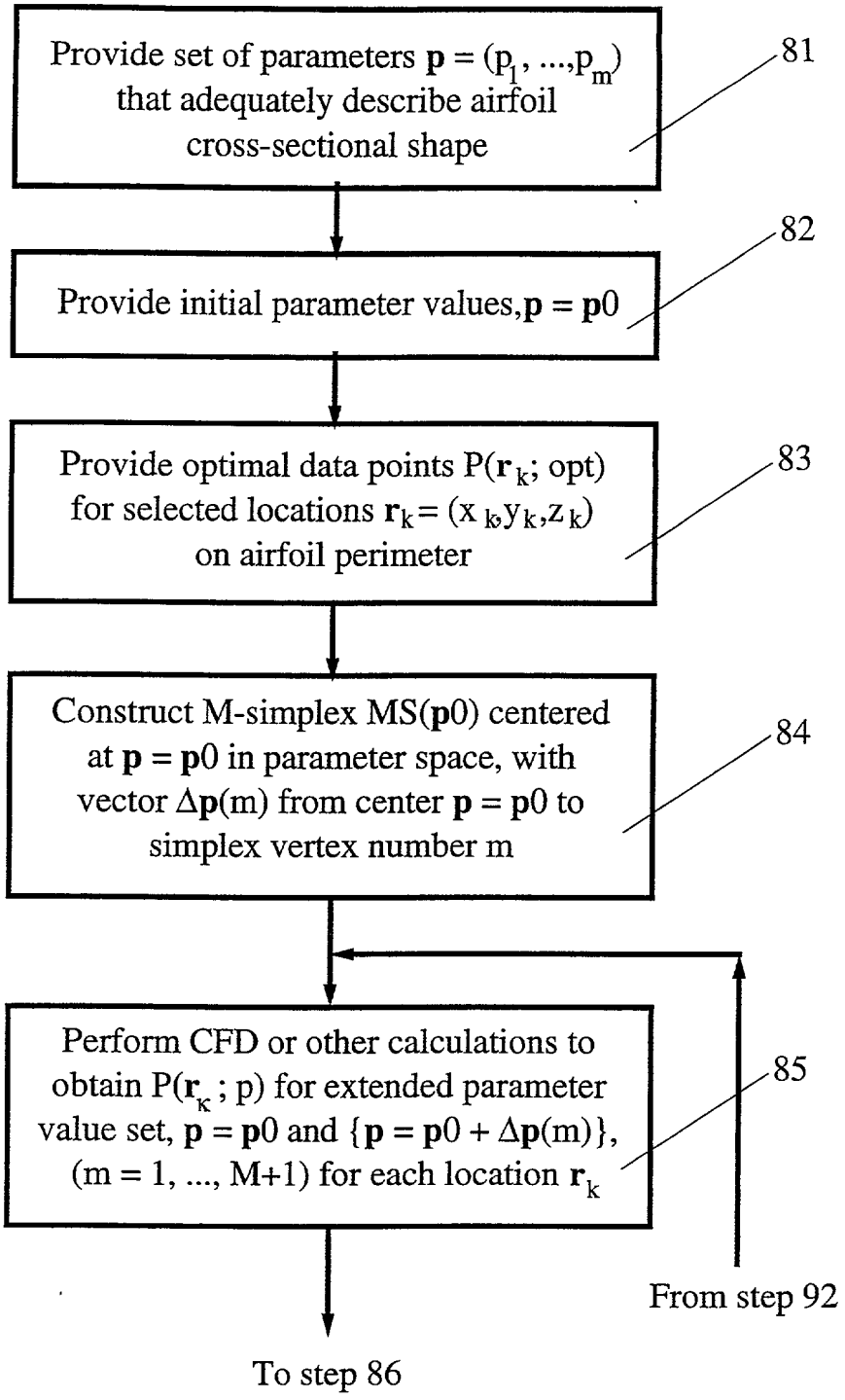
Provide set of parameters $\mathbf{p} = (p_1, ..., p_m)$ that adequately describe airfoil cross-sectional shape
81
Provide initial parameter values, $\mathbf{p} = \mathbf{p}0$
82
Provide optimal data points $P(\mathbf{r}_k; opt)$ for selected locations $\mathbf{r}_k = (x_k, y_k, z_k)$ on airfoil perimeter
83
Construct M-simplex MS($\mathbf{p}0$) centered at $\mathbf{p} = \mathbf{p}0$ in parameter space, with vector $\Delta\mathbf{p}(m)$ from center $\mathbf{p} = \mathbf{p}0$ to simplex vertex number m
84
Perform CFD or other calculations to obtain $P(\mathbf{r}_\kappa ; p)$ for extended parameter value set, $\mathbf{p} = \mathbf{p}0$ and $\{\mathbf{p} = \mathbf{p}0 + \Delta\mathbf{p}(m)\}$, $(m = 1, ..., M+1)$ for each location $\mathbf{r}_k$
85
From step 92
To step 86

FIG. 8A

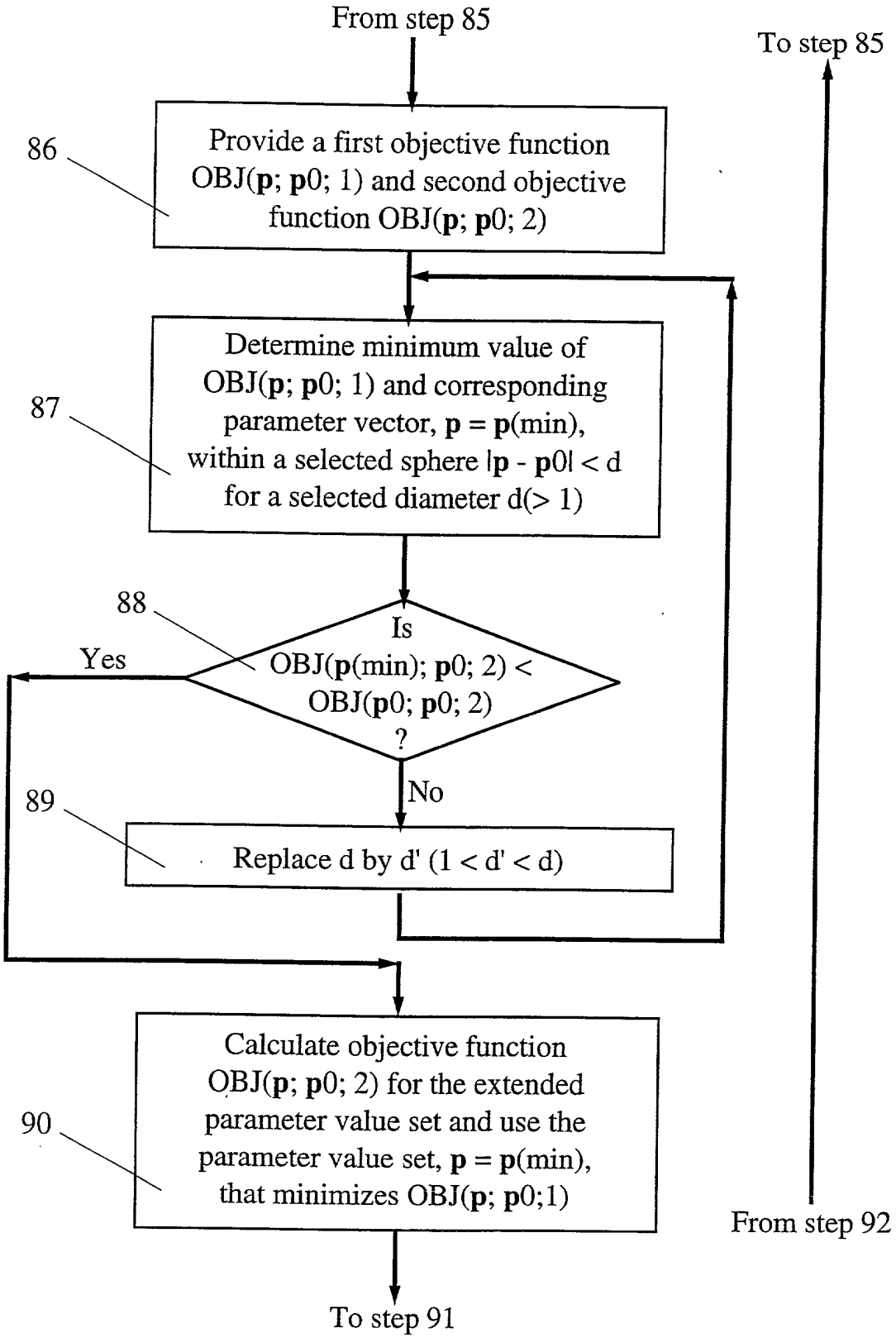
From step 85
To step 85
86
Provide a first objective function OBJ(p; p0; 1) and second objective function OBJ(p; p0; 2)
87
Determine minimum value of OBJ(p; p0; 1) and corresponding parameter vector, p = p(min), within a selected sphere |p - p0| < d for a selected diameter d(> 1)
88
Is OBJ(p(min); p0; 2) < OBJ(p0; p0; 2) ?
Yes
No
89
Replace d by d' (1 < d' < d)
90
Calculate objective function OBJ(p; p0; 2) for the extended parameter value set and use the parameter value set, p = p(min), that minimizes OBJ(p; p0;1)
From step 92
To step 91

FIG. 8B

Title: A Hybrid Neural Network And Support
Vector Machine Method For Optimization
SN: 10/043,044
Inventor: Man Mohan Rai
NASA ARC Docket No.: ARC-14586-1
POC: Vickie L. Kent (650) 604-0887

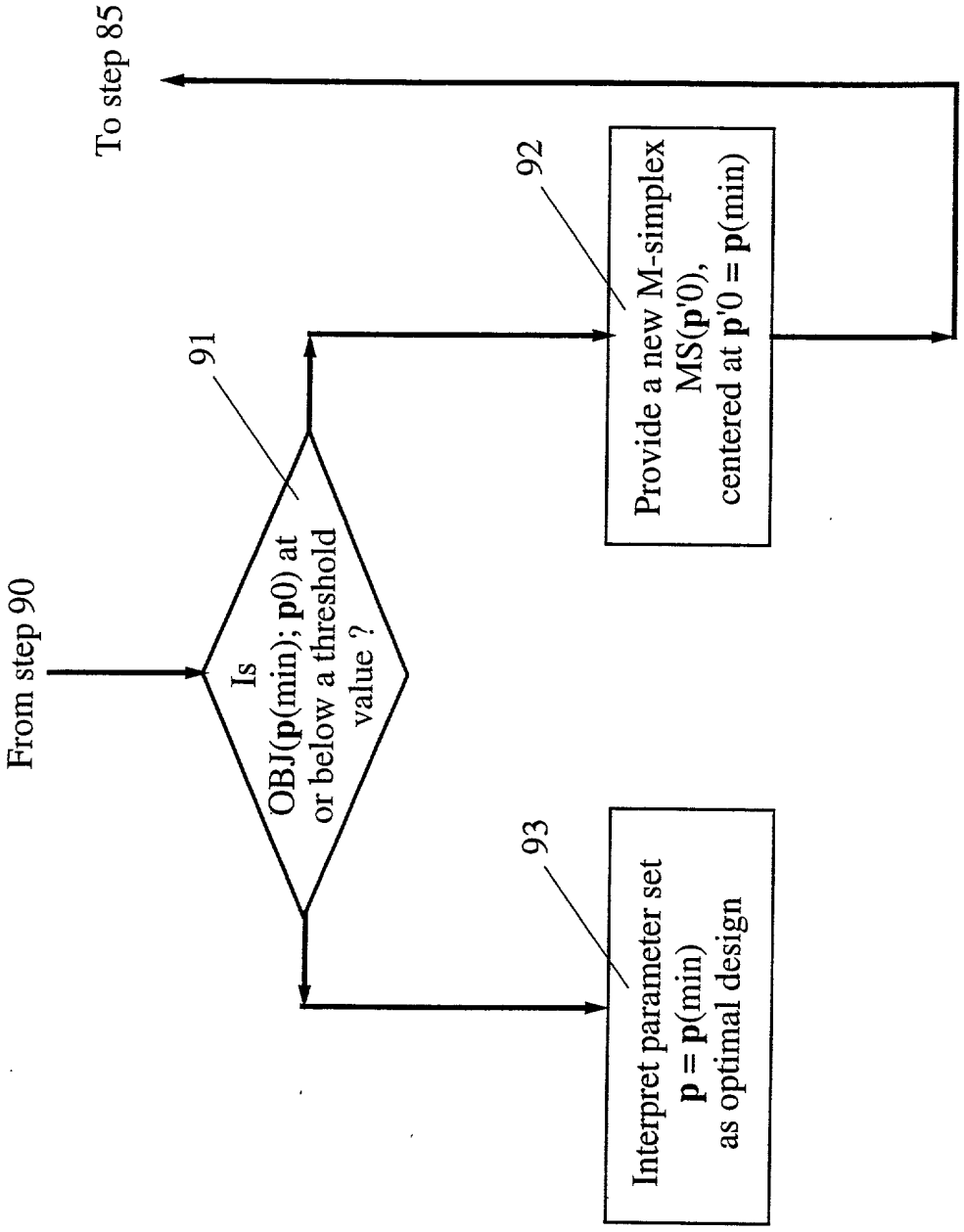

FIG. 8C

Title: A Hybrid Neural Network And Support Vector Machine Method For Optimization
SN. 10/043,044
Inventor: Man Mohan Rai
NASA ARC Docket No.: ARC-14586-1
POC: Vickie L. Kent (650) 604-0887

Optimized airfoil sections and pressure distributions

Target airfoil section
Optimal airfoil sections

Target pressure data
Optimal pressure distributions

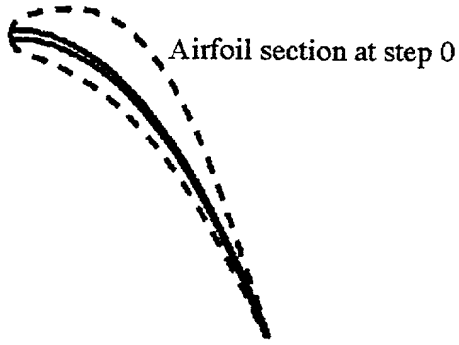

FIG.. 9A-1

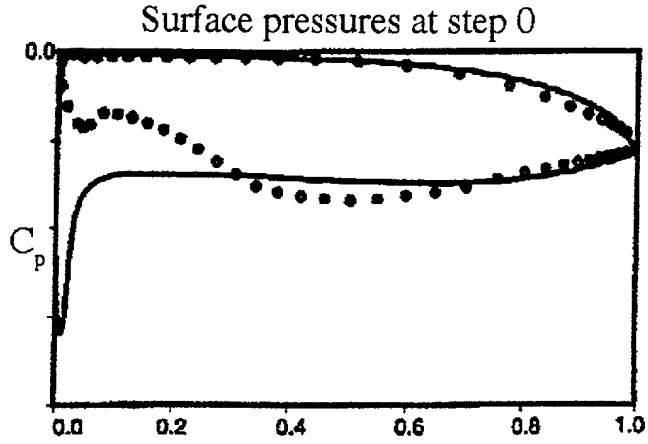

FIG. 9A-2

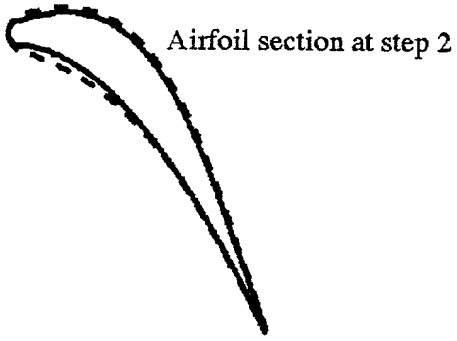

FIG. 9B-1

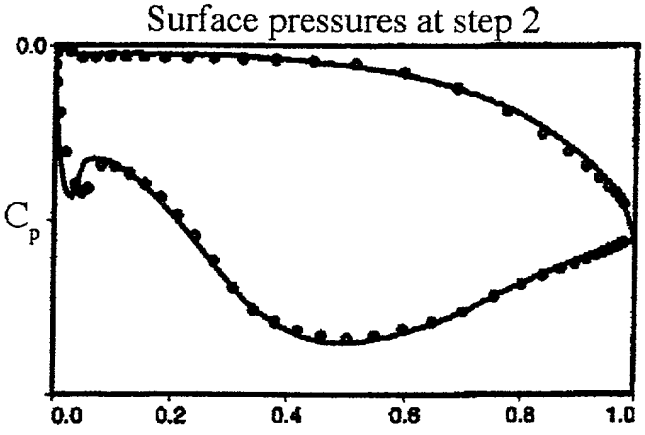

FIG. 9B-2

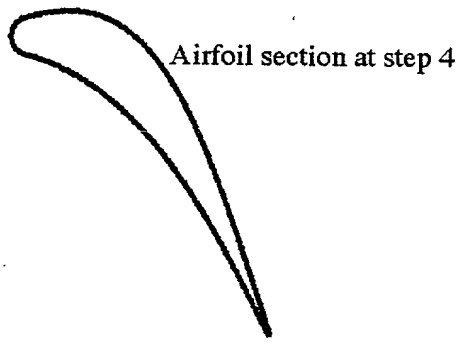

FIG. 9C-1

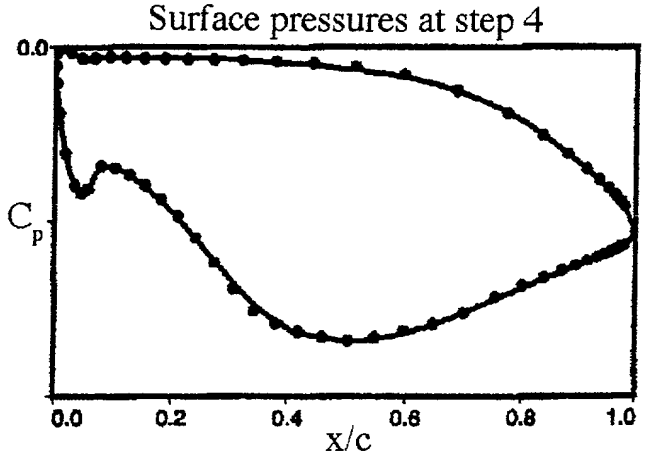

FIG. 9C-2

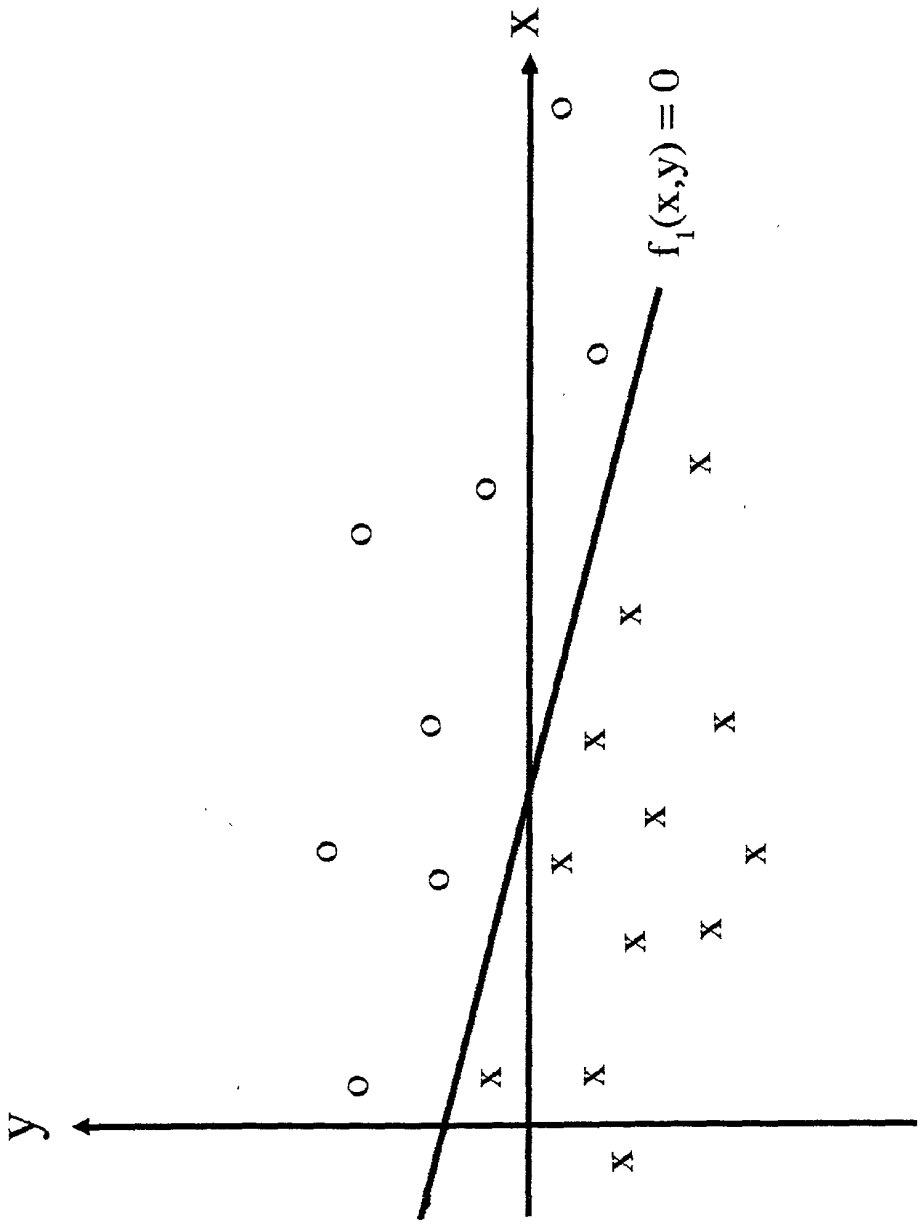

FIG. 10

Title: A Hybrid Neural Network And Support
Vector Machine Method For Optimization
SN: 10/043,044
Inventor: Man Mohan Rai
NASA ARC Docket No.: ARC-14586-1
POC. Vickie L. Kent (650) 604-0887

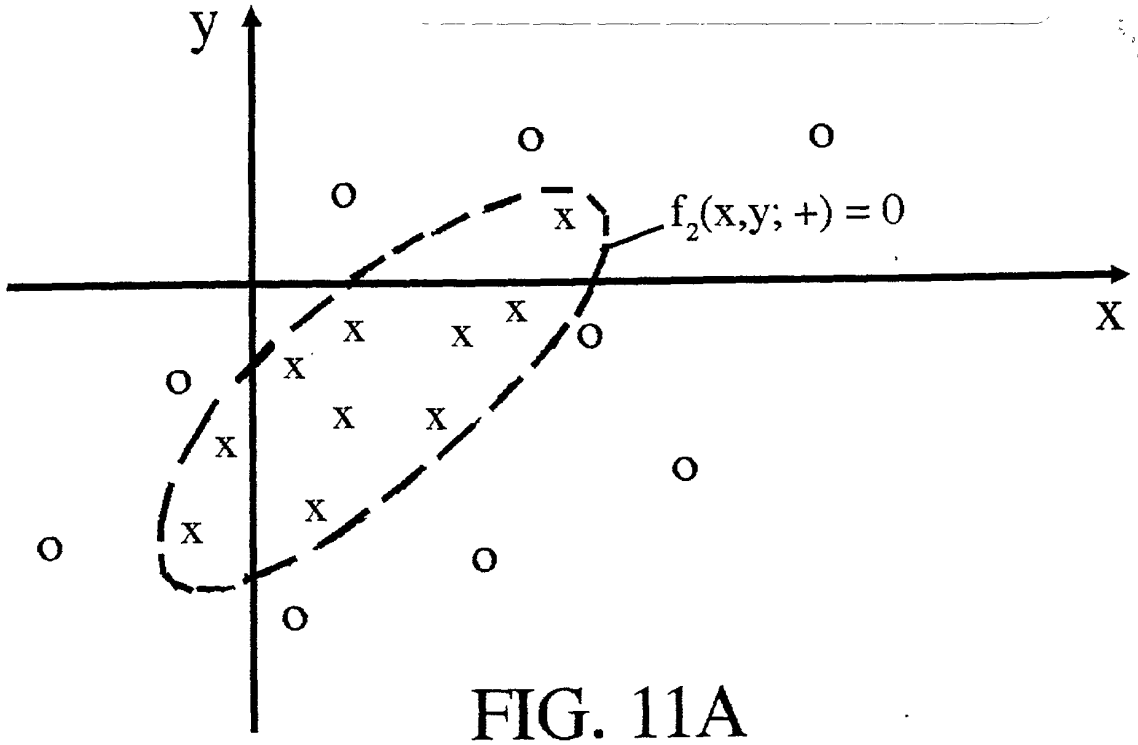

FIG. 11A

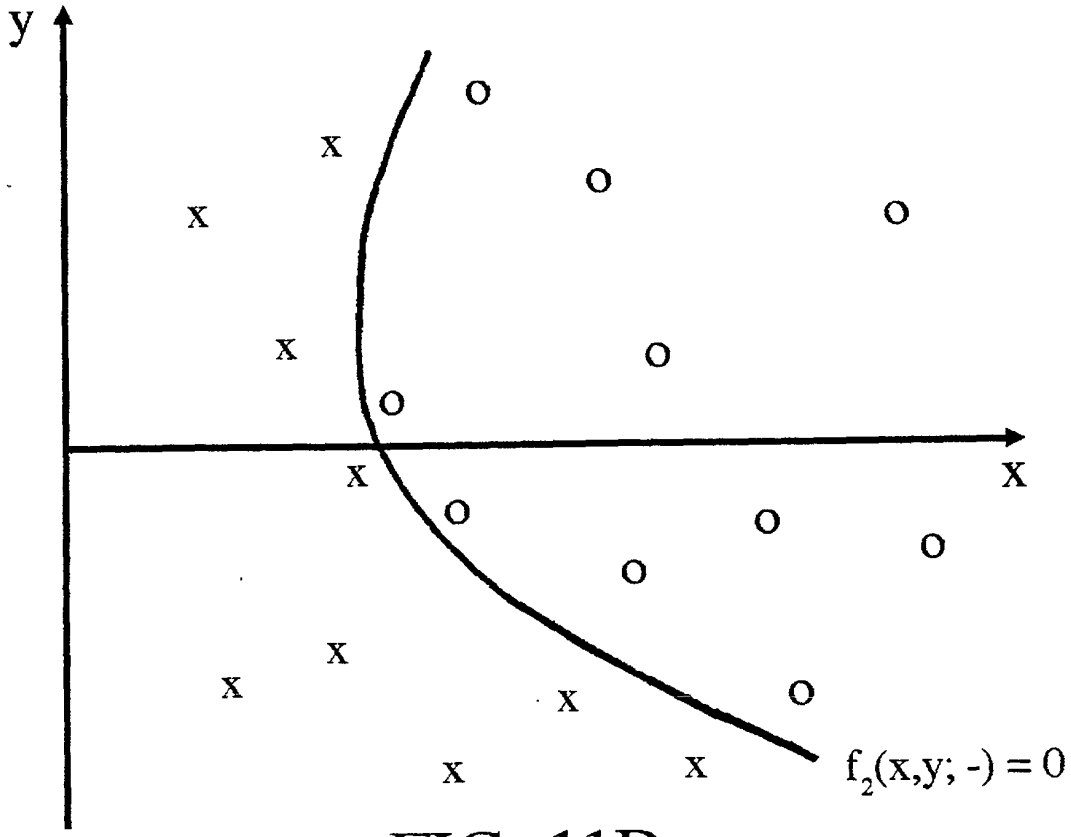

FIG. 11B

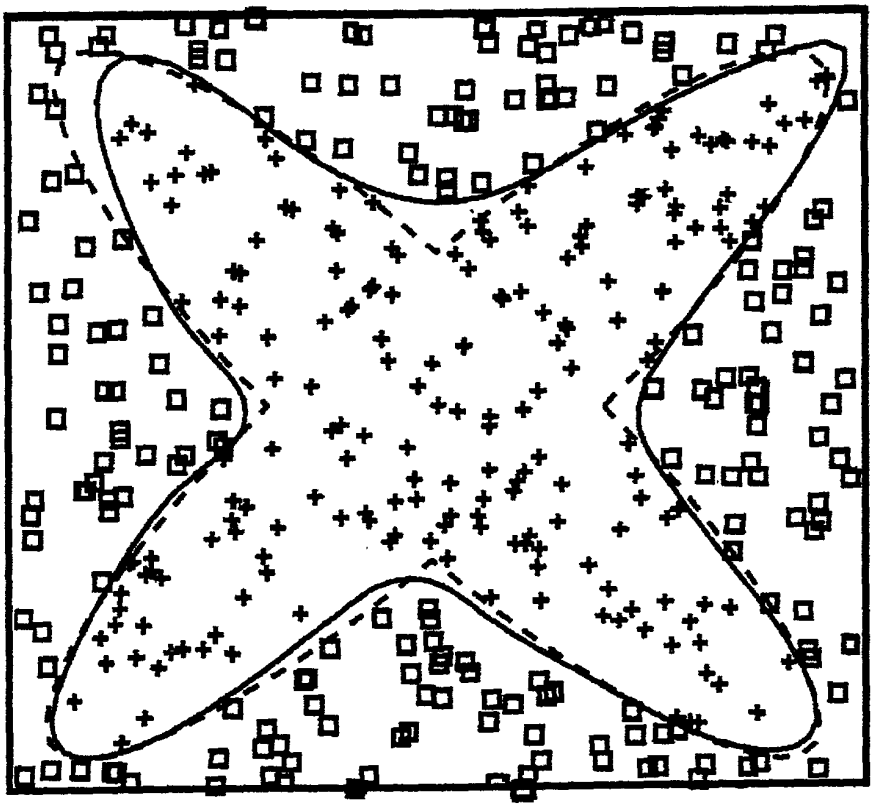

FIG. 12